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Incorporating the precautionary approach into the provision of advice on marine mammals

Intégration de l'approche de précaution à la communication d'avis sur les mammifères marins

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ABSTRACT

Resource management requires tradeoffs between conservation, economic and political concerns in establishing harvest levels. The Precautionary Approach (PA) brings scientists, resource managers and stakeholders together to identify clear management objectives and define management actions that are triggered when a population approaches or falls below agreed upon benchmarks. A conceptual framework for applying the precautionary approach to marine mammals is outlined. For a data-rich species, precautionary and conservation reference levels are proposed. When a population falls below the precautionary reference level, increasingly risk-adverse conservation measures are applied. A more conservative, risk adverse approach is required for the management of data-poor species. This framework has been implemented for the management of commercial seal harvests in Atlantic Canada and can form the basis for the management of marine mammals in across Canada.

RÉSUMÉ

La gestion des ressources exige la recherche de compromis entre, d'une part, des questions de conservation et, d'autre part, des considérations économiques et politiques afin d'établir des limites de prélèvement. Dans le cadre de l'approche de précaution (AP), les scientifiques, les gestionnaires de ressources et les parties intéressées travaillent de concert à fixer des objectifs clairs en matière de gestion et à déterminer des mesures de gestion précises à prendre lorsque la taille d'une population s'approche d'un point de référence ou devient inférieure à celui-ci. Un cadre conceptuel d'application de l'approche de précaution à la gestion des mammifères marins est mis en avant. Pour les espèces bien documentées, un seuil de précaution et un seuil de conservation de référence sont proposés. Lorsque la taille d'une population passe sous le seuil de précaution de référence, des mesures de conservation de plus en plus prudentes sont mises en œuvre. Une approche de précaution encore plus stricte doit être adoptée pour la gestion des espèces moins documentées. Ce cadre a été mis en œuvre pour la gestion des prélèvements commerciaux de phoques du Groenland au Canada atlantique et pourrait servir de base à la gestion des mammifères marins pour l'ensemble du Canada.

INTRODUCTION

Adopted in 2003, the Atlantic Seal Management strategy is an example of an approach to incorporate the precautionary approach into the delivery of Science advice for the management of marine mammals. Also known as Objective Based fisheries Management (OBFM) it was developed in response to the Eminent Panel report on seal management (McLaren et al. 2001). OBFM provides a framework that identifies precautionary and critical reference limits which define healthy, cautious and critical zones of abundance, along with management actions that are triggered when thresholds are exceeded to reduce potential damage to the resource. Although DFO has historically identified case-specific approaches to the management of different populations, this is an immense undertaking and extremely time consuming. Applying a generalized approach to all marine mammals provides a consistency across populations that can be applied efficiently. This discussion paper is based largely on Hammill and Stenson (2003, 2007) and discussions within the ICES/NAFO Working Group on Harp and Hooded Seals (ICES 2004, 2006a, and b, 2008). The objective of this paper is to describe the general approach using Atlantic seals as an example, and then identify some of the issues that must be addressed if the approach is to be applied more widely to the management of marine mammals in Canada.

Within the context of fisheries management, the Precautionary Approach (PA) strives to be more cautious when information is less certain, does not accept the absence of information as a reason for the failure to implement conservation measures, and defines, in advance, decision rules for stock management when the resource reaches clearly stated reference points (Punt and Smith, 2001). These points or levels are referred to as Conservation (Limit), Precautionary and Target Reference Points (ICES 2001). One of the basic principles of PA is the need to account for the uncertainty associated with estimates and to develop a basis for taking action in cases with insufficient scientific understanding. Thus, protocols are needed for situations where considerable data are available ('data-rich') as well as for situations where information concerning the resource is more limited ('data-poor').

OBJECTIVE BASED FISHERIES MANAGEMENT (OBFM) FRAMEWORK

The amount of information available for resource management varies between species. Therefore, it is necessary to define situations where there is considerable information on the population dynamics of a population as 'data-rich' and situations where data are more limited as 'data-poor'. For Atlantic seal management, data-rich species require three or more abundance estimates over a 15 year period, with the most recent estimate obtained within the last five years. Current information (≤5 years old) on fecundity and/or mortality are also required in order to determine sustainable levels of exploitation. If these data are not available, the species would be considered as 'data-poor' and a more conservative management approach required.

DATA-RICH SPECIES

For data-rich species, a conservation (or limit) reference point, referred to as $N_{Critical}$ can be established based upon (estimated) abundance (Fig. 1). This is the level at which continued removals are considered to cause serious and irreversible harm to the population. However, estimates of abundance are associated with considerable

uncertainty and this uncertainty increases as the population is projected into the future. Managing a population close to the conservation reference point would result in a significant likelihood that the population was below the critical limit before appropriate management action could be taken. Therefore, a Precautionary Reference Point (N_{Buf}) must be identified that identifies a 'cautionary' population range within which specific management control rules, designed to conserve the population, would apply. When a population is abundant and above the precautionary reference point, managers, in consultation with stakeholders, can establish a target reference point based upon considerations such as ecosystem impacts and/or socio-economic benefits. As long as the population remained above N_{Buf1}, higher risk harvest strategies could be adopted. However, there is always uncertainty associated with the available data, population models and future environmental conditions. Therefore, the uncertainty associated with the population estimates must be explicitly considered and there be a high probability that the population is above the reference level in order to be considered in the 'healthy' zone.

If the population is in the cautious zone (i.e. below the precautionary reference point but above $N_{Critical}$) conservation becomes a higher priority and pre-agreed harvest control rules would be applied with the objective to return the population to a level above N_{Buf} within a specified period of time (e.g. 10 years or less). Although harvesting and other human induced removals could continue, management strategies would require a high probability that the population would increase or conversely, a lower risk that the population would continue to decline. Various approaches can be used to determine the control rules applied to populations below the precautionary reference point. A single control rule could be applied as long as the population was above the critical level, or alternatively, a variable control rule may be applied so that the level of conservation is proportional to how close the population is to the critical level. Another approach would be to divide this 'cautious' zone into two halves. In the upper, conservation is important while in the lower (below a second buffer point N_{Buf2}), conservation becomes an even higher priority, such that significant conservation measures are required. For example, the control rules could be designed so that if a population is in the upper half of the cautious zone harvest strategies are required to have an 80% likelihood that the population will increase and exceed N_{Buf} within 10 years while management measures for populations in the lower half require a higher likelihood (95%) of increase.

If a population is below $N_{Critical}$, the population would be considered to be a conservation concern and that there is an unacceptable risk of serious or irreversible harm. Under this situation, management actions would be taken to ensure that all human induced mortality was eliminated.

One of the greatest challenges is to determine the population levels at which the reference points should be set. Ideally, the reference points would be selected after extensive simulation studies are completed. However, such studies are time consuming and can result in delays in implementing the precautionary approach. For example it took 12 years to complete the implementation trials under the International Whaling Commission Revised Management Plan for western North Pacific minke whales (Punt and Donovan 2007). This process has proven to be quite onerous and although guidelines have been adopted to smooth the process, it is felt that the process would probably still take 2 years to complete. Therefore, it is often better to implement a management approach with reasonable reference levels that can be refined later as additional information becomes available. Setting N_{Buf} at a level equal to, or greater than, Maximum Sustainable Yield (MSY) has been proposed for a number of fish species (e.g. ICES 2001). However, MSY

is difficult to determine for many species and even in cases where it can be estimated in a retrospective analysis, an MSY estimated during one time period might not be appropriate to a population living under a different set of environmental and biological conditions (Punt and Smith 2001). Another approach is to use the framework developed within the International Union for the Conservation of Nature (IUCN) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) for assessing the status of populations (IUCN 2001; COSEWIC 2006). When these guidelines were developed, terrestrial mammals were one of the major groups considered. In this approach, species are assigned to categories of concern based on a percentage decline in abundance of 30%, 50% or 70% from a reference population size. Using the COSEWIC/IUCN framework, the first precautionary reference point, N_{Buf}, could be set at 70% (N_{70}) of the maximum observed (or inferred) population size. N_{Buf2} could be 50% (N_{50}) of the maximum observed population size and $N_{Critical}$ could lie at 30% (N_{30}) of the maximum (Fig. 1). Although this approach lacks a strong mathematical basis for its structure, it moves the debate away from a concept that is in itself controversial (i.e. MSY), and instead shifts the focus towards benchmarks that are clearly defined, and are in keeping with magnitudes of change in species abundance (30%, 50% and 70%) that are considered important enough to be of concern. Using the relative decline from a historical abundance estimate to trigger management concern has been recommended in other jurisdictions. For example Mace et al (2002) recommended that a decline to 30% of historical levels be considered as serious for low productivity species. Setting N_{Buf} at 70% would ensure that the population would remain above this threshold even if it declined at a moderate rate (8%) for 10 years. Given the timing for most marine mammal surveys, this is the minimum period required to detect a change in most populations.

Many of these approaches suggest that reference points be established with respect to a pristine size. However, estimating virginal levels is difficult, especially when populations have been subjected to varying ecological and/or environmental impacts. As a result we have related the reference points to estimates of the maximum population seen or estimated.

DATA-POOR SPECIES

For species that do not satisfy the data-rich criteria, the uncertainty associated with the resource's status and the impact of a particular management action is much larger and, as a result, a very risk adverse approach is needed. The Potential Biological Removal (PBR) is a very conservative, risk adverse approach that was developed in response to the United States Marine Mammal Protection Act (MMPA, Wade 1998). The objective of the MMPA is to maintain the population above 'optimum sustainable population' (OSP) levels which correspond to 50-80% of the estimated pristine population size (i.e. similar to our N_{Buf}). Although there is no commercial harvesting of marine mammals in the United States, animals are taken as by-catch in other fisheries. As long as these levels of incidental catch do not exceed the PBR level, they are not considered to pose a conservation threat to the population (i.e they will increase to the OSP or, if already above, OSP, will remain there). PBR can be calculated from the formula below:

$$PBR=0.5 \cdot R_{Max} \cdot F \cdot N_{Min}, \qquad (1)$$

where R_{Max} is the maximum rate of increase for the population, F is a recovery factor with values between 0.1 and 1 and N_{Min} is the estimated population size using 20th percentile

of the log-normal distribution (Wade and Angliss 1997; Wade 1998). We set F at 1, unless there is a serious conservation concern. The only data required to calculate PBR is an estimate of population size, making it appropriate for data poor species. Rigorous simulation testing has shown that it is robust when the model assumptions were relaxed and plausible uncertainties were included (Palka 2002).

For data poor species for which a maximum population can be estimated, $N_{Critical}$ could be established using a similar approach to that used for 'Data-rich' species. Above $N_{Critical}$ the PBR approach could be used to set a conservative harvest level. If the population is below $N_{Critical}$, then no harvest would be allowed. If no maximum abundance information is available, $N_{Critical}$ could be defined using the IUCN criteria for 'vulnerable' species (ICES 2006).

We have recommended that for data-poor populations, an estimate of PBR be used to estimate allowable removals. The benefit of using PBR is that it is easy to estimate, requires little data and if catches remain below PBR, the risk of a further decline in the population is low (Palka 2002). On the other hand, the PBR approach does not make use of all available data, it assumes that all age classes are harvested in proportion to their abundance in the population and catches are constrained to very low levels, with significant economic loss. For populations meeting the data-rich criteria (e.g. harp seals), however, more detailed population models can provide reasonable predictions to ensure that larger catches do not pose a conservation risk to the population.

SEALS IN ATLANTIC CANADA

The commercial seal hunt in Atlantic Canada focuses on three species - harp (*Pagophilus groenlandicus*), hooded (*Cystophora cristata*) and grey seals (*Halichoerus grypus*). In addition to the commercial hunt, which has been ongoing since the 18th Century (Sergeant 1976,1991), Northwest Atlantic harp and hooded seals are also hunted for subsistence purposes in the Canadian Arctic and Greenland.

Harp seals satisfy the requirements for a 'data-rich' species, with a series of eight abundance estimates, the most recently completed in 2004, as well as information on harvest levels and age specific reproductive rates (Hammill and Stenson 2005). In 2005, the population was estimated to be 5.82 million (95% CI: 4.1-7.6 million) seals (Fig. 2) which is the largest population that has been documented. The current management objective is to maintain the population above N_{70}, i.e. above 4.07 million seals (DFO 2003, Fig. 1 and 2). To account for the uncertainty associated with the current population estimates as well as the increasing uncertainty as trends in the population trajectory are projected forward in time, the management objective for Atlantic seals is to ensure an 80% probability that the population will remain above N_{70} (Fig. 2). If the population were to fall below N_{70}, then a control rule stating that harvests must be set at a level that insures an 80% probability that the population will increase above N_{70} within 10 years (DFO 2008).

In contrast, Northwest Atlantic hooded seals are considered to be data poor due to a lack of adequate estimates of pup production, uncertainty in stock structure and the limited reproductive data available. However, based on a 2005 survey, the estimated population size in 2005 was 594,000 (95% CI: 466,000-728,000, CV=17%) (Fig. 3; Hammill and Stenson 2006). The minimum population size would be 535,000 animals, resulting in a PBR estimate of 32,000 animals (rounded to the nearest thousand). Taking into account

the current subsistence harvests in Greenland (approximately 7,000, Stenson 2006), and accounting for animals killed, but not reported would result in an allowable Canadian harvest of about 8,000 animals under PBR.

Until recently, grey seals were considered to be data poor and allowable quotas were set using a PBR approach (DFO 2003, 2006). In 2008, the TAC was set 2,000 seals in the Gulf of St. Lawrence and 10,000 on the Scotian Shelf (to be taken over two years, DFO 2006). However, with the completion of recent surveys and additional data on reproductive rates, the population is now considered to belong in the data rich category (DFO 2008). Based on surveys carried out in 2007, the population was estimated to be 304,000 (95% CI: 242,000-371,000; DFO 2008). Quotas for 2009 are being considered based upon the data rich approach.

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA (ICES)

Efforts to adopt a Precautionary Approach to wildlife management are ongoing in a number of jurisdictions. In order to develop such an approach for the management of harp and hooded seals in the northeast Atlantic, the Joint ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP), proposed that ICES adopt an approach similar to that of OBFM (ICES 2004). They also noted that the use of MSY and carrying capacity of the environment ('K') were not appropriate for these species and identified a minimum precision (CV <30%) for surveys. ICES accepted the general approach and in 2005, WGHARP further refined the approach to require that abundance estimates must be unbiased and that at least three abundance estimates should be available spanning a period of 10-15 years in order for a population to be considered 'data rich' (ICES 2006a). They also stated that if no recent (i.e. <8 years), accurate abundance estimates are available, no harvest should occur. Using these criteria they recommended that all hunting of the Greenland Sea population of hooded seals, which are considered to be a data poor species currently below $N_{Critical}$ be stopped (ICES 2006b). This recommendation was subsequently accepted by the Norwegian-Russian Sealing Commission. WGHARP has also recommended that if a data poor population is considered to be above N_{lim}, a recovery factor (F) of 0.5 should be used if the population is considered to be decreasing or have an unknown status while F=0.75 for populations thought to be increasing (ICES 2006b).

In response to the a management framework for seals similar to OBFM that was proposed by Norway, WGHARP further clarified their approach by recognizing the need to account for uncertainty in the abundance estimates and identifying a rebuilding plan for depleted populations (ICES 2008). They proposed that for species above N_{70}, a given harvest should have an 0.8 probability that stock size will remain above N_{70} 10 years in the future. For populations initially above N_{50} but below N_{70}, there should be an 0.8 probability that stock size will be above N_{70} 10 years in the future and for populations below N_{50} but above N_{lim}, there should be an 0.8 probability that the population size will be above N_{50} 10 years in the future.

ALTERNATE APPROACHES: THE INTERNATIONAL WHALING COMMISSION

An alternative approach to a PA compliant management plan, called the Revised Management Plan (RMP), has been developed by the International Whaling Commission

(IWC 1994). The RMP was established with specific management objectives that were clearly identified. These included: maintaining a population above a limit reference point of 54% of the estimated carrying capacity; catches were to remain as stable as possible, and to allow the highest possible yield without the population declining below the limit reference point. The advantage of the RMP is that substantial simulation testing has been carried out to test the behaviour of the catch limit algorithm under conditions when reasonable assumptions to model conditions and estimates of abundance are not met. At the same time the RMP is relatively complex, has very large data requirements, and has yet to be applied in a commercial context.

ADDITIONAL CONSIDERATIONS

Although the basic approach used to incorporate the PA into the management of seals can be applied to other species in Canada, some issues still need to be clarified or decided. For example, WGHARP has identified a species rebuilding plan for species below N_{buf}. Although DFO has identified that when a population is below N_{70} (but above N_{50}) management action must ensure that the population is above N_{70} within 10 years, there is currently no pre-agreed management action for a population that is below N_{50} but above N_{lim}. The need to identify such a control rule must be identified.

The framework developed here relies on estimates of maximum population size to scale subsequent precautionary and critical reference limits. Under OBFM, these levels are set as a proportion of the maximum population size known or inferred. This approach is conservative since for increasing populations the levels will also increase, while for declining populations the levels will remain unchanged. It is often difficult to explain to managers and the general public why the reference levels can change when new information becomes available. In contrast, some approaches (e.g. IWC, MMPA) express population status as a proportion of estimated pristine population size developed from historical records. Using maximum surveyed population size, as done for Atlantic seals, provides an estimate based on accepted survey approaches, but may be measuring an already depleted population. However, using pristine estimates to determine maximum population size may be based on unreliable data, with unknown sources of bias and may apply to population sizes that existed under different ecosystem conditions (shifting baseline syndrome for better or for worse).

The PBR approach used for data poor species includes a recovery factor that lies between 0.1 and 1. A factor of 1 may apply to a population that is abundant, whereas a factor of 0.1 under the United States system applies to populations designated as endangered. WGHARP applies a factor of 0.5 or 0.75, depending on the direction of change in the population. To date, Canada has used a factor of 1 since the use of PBR for data poor species is considered to be already conservative. Choice of this recovery factor can have serious implications in setting TAC levels and therefore, it is important that we identify criteria for choosing appropriate levels.

The specific criteria required to consider a population as 'data rich' may vary slightly among species groups. For example, the level of precision attained for seal surveys may not be achievable for whale surveys. We feel that it is important that the general approach be consistent and that each individual population not be treated independently, but some general principles may vary among larger groups.

Under the framework identified here, removals from all sources are to be included when estimating TAC levels. In the traditional sense this includes removals from Canadian and international hunts (commercial and subsistence), as well as removals via incidental catches in other fisheries. In Atlantic Canada, bycatch of harp seals in lumpfish fisheries have in some years been particularly high. However, this approach also provides a framework that can incorporate any source damage or removals. As such it may be a way to incorporate the impact of mortality from other human activities such as seismic, vessel traffic or contaminants into the management process.

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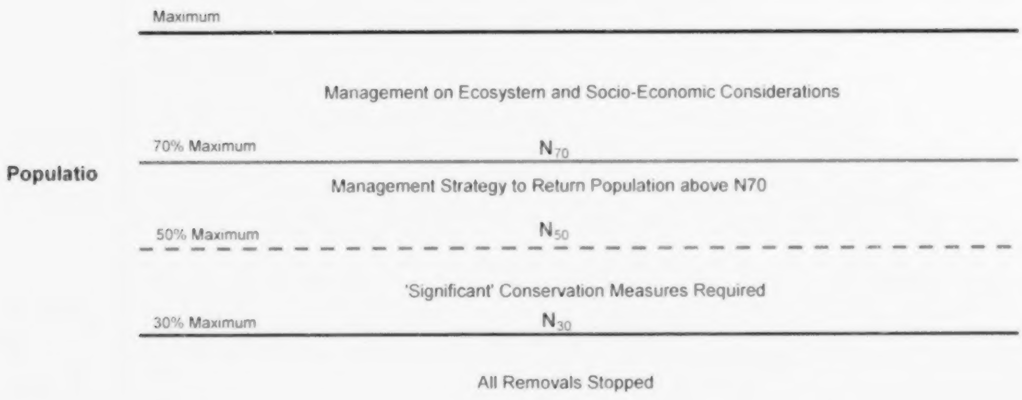
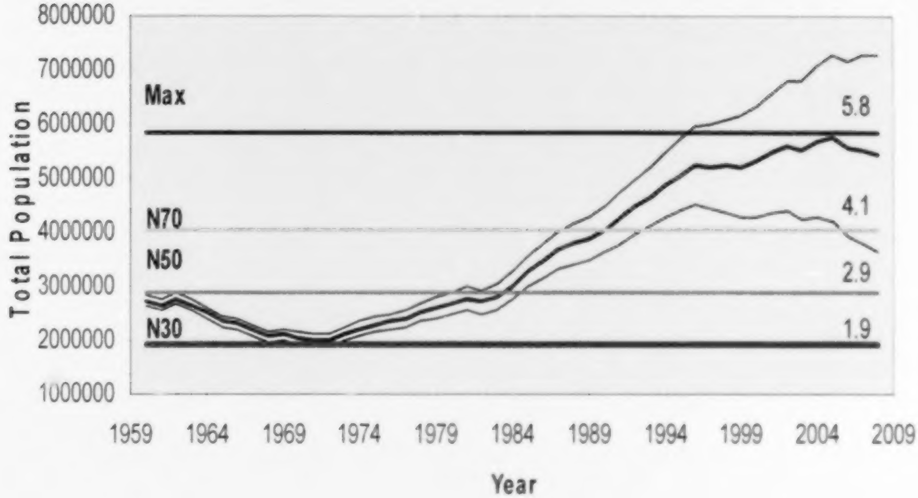


Figure 1. Reference points for management of data rich species. Population numbers on the right represent application of framework to management of NW Atlantic harp seals.



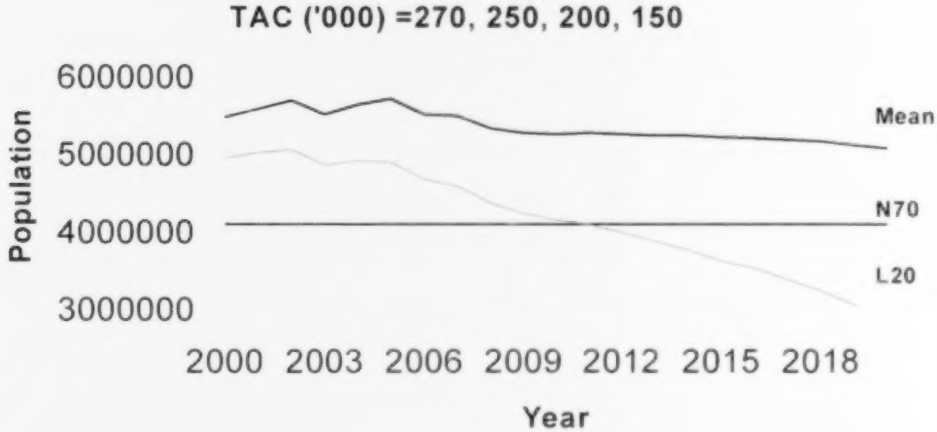


Figure 2. Estimates (± 95% CI) of total population size and precautionary and critical reference limit levels used under OBFM for management of Atlantic harp seals (Top). Change in modeled population trajectory under a scenario of annual harvests of 270, 250, 200 and 150 thousand animals over 4+ years. Trends show changes in the mean estimate of population size and the lower 20% probability level.

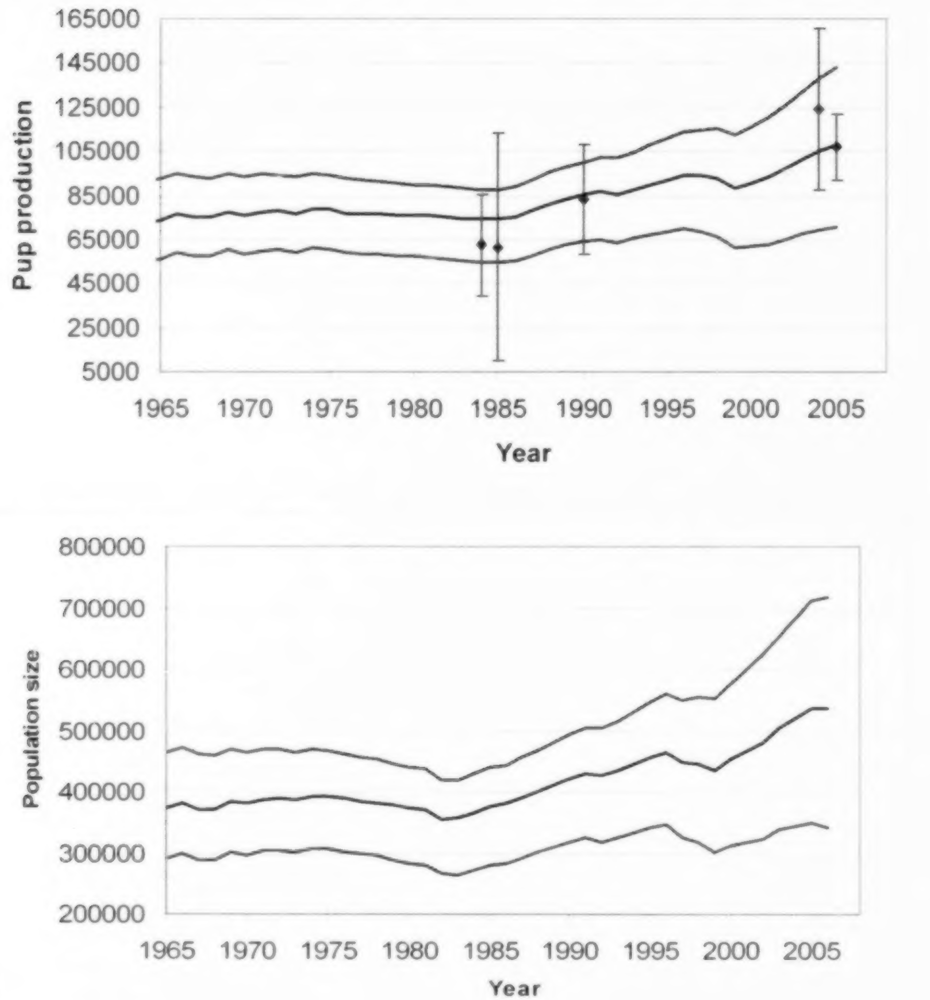


Figure 3. Estimates (± 95% CI) of pup production of Northwest Atlantic hooded seals from 1960 to 2005 obtained from independent surveys (top) and estimates (± 95% CI) of total population size as indicated from a population model (Hammill and Stenson in prep.).